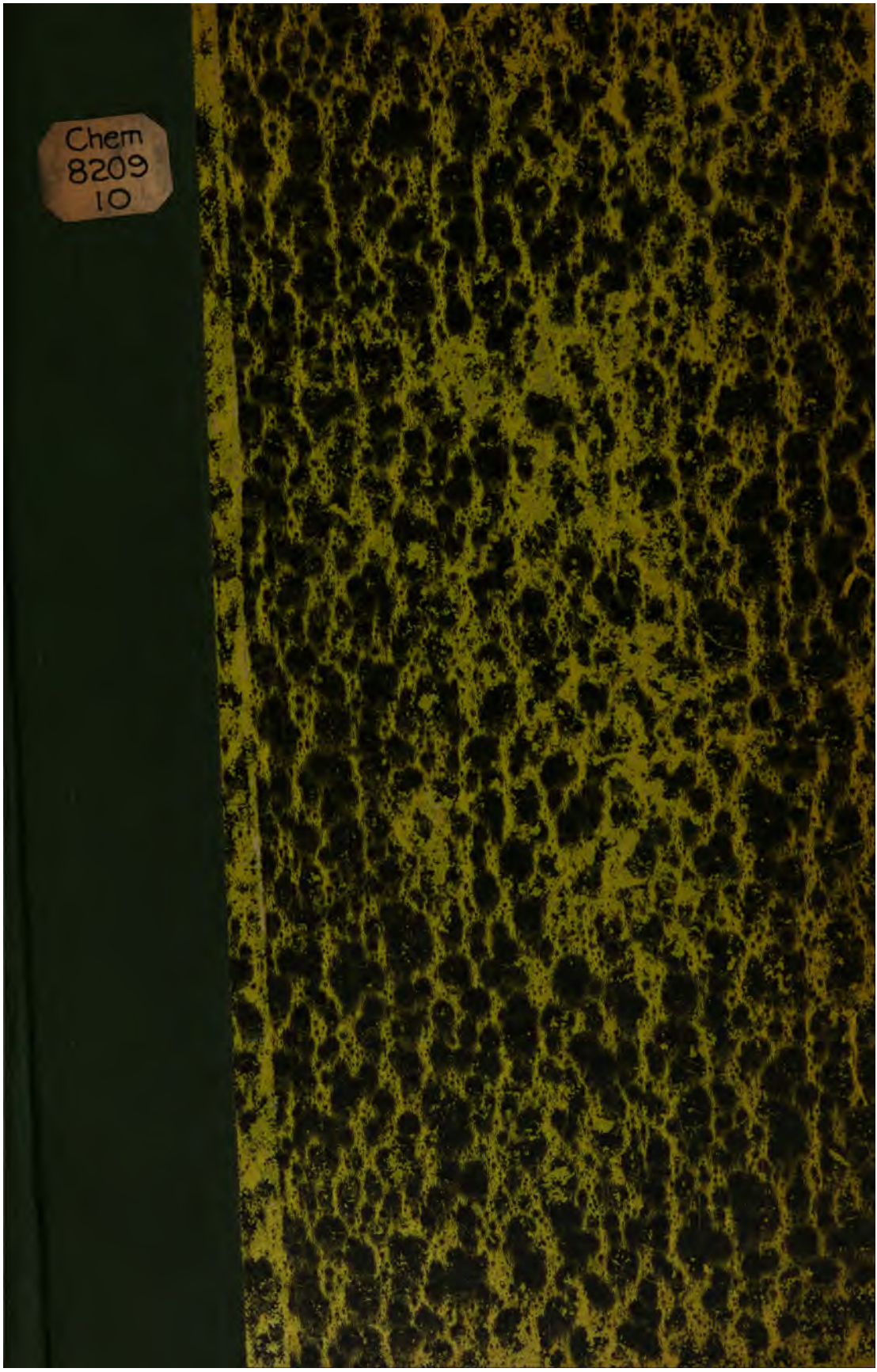

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CONTRIBUTIONS TO ENGINEERING CHEMISTRY
BY MEMBERS OF THE STAFF OF
ARTHUR D. LITTLE, Inc., CHEMISTS & ENGINEERS

B THE BASIS OF QUALITY IN PAPER

BY

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OFFICIAL CHEMIST, AMERICAN PAPER AND PULP ASSOCIATION

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The Basis of Quality in Paper

By ARTHUR D. LITTLE

WHEREAS a few not greatly varying sorts of paper were enough to satisfy the very moderate requirements of our grandfathers, the development of modern conditions has brought such complexity into social and commercial life, and extended so enormously the range of industry as to increase by many thousandfold the demands of the community upon the paper maker. In his efforts to meet these demands the paper maker has been greatly aided by countless discoveries and inventions, without which indeed the demands could not have been met at all. New sources of raw material, new methods of treatment, new machines, and altogether new agencies of many kinds have been added to the resources of the art. As a result the consumer now finds available for his widely-diverse purposes thousands of kinds of paper which exhibit in their composition and properties the extremes of possible variation in a multitude of factors.

Amid such bewildering variety how is quality to be determined? What constitutes the basis of quality in paper?

The Germans long ago, after extended investigation, established and have since developed and maintained under government regulations, a system of classification of papers based on their composition and physical properties. This classification or definition of so-called "Normal Papers" has since attained a considerable acceptance in countries other than Germany and has come to be regarded as constituting a series of standards of quality in paper. Valuable

as this system of classification has proved itself to be to both users and makers of paper, and indispensable as the refined and accurate testing methods which it involves have become for the intelligent selection of papers, it remains true, nevertheless, that, taken by itself, or as applied to any particular papers without reference to their intended use, it is without significance as to quality. There is, in a word, no such thing as a general basis for quality in paper, and no other possible basis for quality in case of any particular paper than its suitability for its intended use. Good writing paper is bad blotting; good news print is poor wrapping; good book paper is an impossible cigarette paper; and so on. In no case can the properties of good paper be defined until the specific use for which the paper is intended has been stated or assumed. The properties which confer high quality upon a paper intended for one purpose are precisely those which condemn it for another. Stretch is a desirable property for a bag paper, it may be fatally objectionable in paper for lithography; opacity is a principal element in determining the quality of bible paper, transparency is equally important in pergamyn and glassine papers. Certain grades of book papers base their claims to quality mainly upon the extent to which they bulk for weight; the buyer of wrapping paper should consider, on the other hand, area for weight in determining quality.

Keeping clearly in mind, then, the conclusion that the basis of quality in paper must always be found in the relation of the properties of particular papers to the intended purpose of these papers, let us consider the more important properties of the material and their relation to particular uses.

In case of a thing so apparently simple in its make-up as a sheet of paper, an extraordinary number of factors are involved in any consideration of its quality. Many of these factors are elusive, in the sense of evading exact definition or determination, but they are none the less important, or even at times decisive, on that account. Such, for example, are permanency, feel, texture, finish, rattle, tear, formation,

fastness of color, distinctness and artistic quality of water-marking, dirt, softness, hardness, hairiness, or "whiskers," distinctive appearance, "color" of white papers, printing quality and ability to withstand erasure. As to most of these properties reliance must be placed upon expert judgment and comparison with standard or accepted samples of generally similar papers. Permanency, however, is largely a function of composition, and the composition of a paper can be determined with a considerable degree of accuracy. No paper, therefore, which is intended for permanent records should contain ground wood, unbleached fiber of any kind, acid, sulphur, soluble chlorides, or more than a moderate amount of ash. Preferably, it should be free from resin, and in the absence of conclusive proof of the permanent character of papers made from well prepared chemical wood fibers, preference should be given to all rag papers. Since over-bleaching hastens the deterioration of fibers, extreme whiteness is undesirable in the sheet.

In case of papers for ephemeral uses, permanency has, of course, little bearing upon quality. For printing upon fast perfecting presses, newspaper is better paper because of the large proportion of ground wood it contains, and to which it owes in great measure its special printing quality.

Fastness of color, while not permitting of exact quantitative determination, can, nevertheless, be tested experimentally with sufficient accuracy for most purposes, while very definite conclusions may often be drawn from the known degree of fastness of the dyes or pigments from which the paper derives its color. Fastness of color is of comparatively little importance as affecting the quality of papers intended to serve a temporary purpose. It becomes of prime importance in wall papers, etching, photograph mounts, plate papers, map and fine book paper. Similarly uniformity of color has slight influence on the quality of small lots of paper, especially if these are to be used as single sheets. It does bear directly upon the quality of paper for serial publications which are to be bound together. With the invention of the Ives Colorimeter the color of

paper has fortunately become a property permitting of exact measurement and definition.

For almost all purposes the presence of a noticeable amount of dirt is regarded as detrimental to the quality of paper. It not only detracts from the appearance of the paper, but its presence may be indicative of the use of inferior or carelessly prepared material. In some few cases, as with wrappers made from screenings, the dirt may be so considerable in amount, and so uniformly distributed as to become an integral and characteristic part of the paper, while as with certain Japanese papers dirt in the form of unreduced bark or vegetable tissue may be so disposed within the sheet as to actually enhance its quality from the artistic standpoint. While it is not easy to give numerical expression to the amount of dirt present in a sheet, the experienced paper maker or paper buyer has no difficulty in making close comparisons in this regard. It is by no means so easy to estimate exactly the bearing of relative amounts of dirt upon quality.

Fortunately, what may be called the fundamental properties of paper permit in nearly every case of exact measurement and numerical statement. These fundamental properties are thickness, weight per unit area, resistance to bursting strain, tensile strength in different directions, stretch, ability to resist wear, tendency to absorb ink or water, opacity. Furthermore, these properties are largely determined by the composition of the paper, and the care and skill with which its material has been prepared and manipulated during manufacture. Fortunately, again the composition can be accurately determined by chemical and microscopical examination while at the same time many direct and important inferences may be drawn from these examinations as to the course and nature of the processes of manufacture.

Of all the fundamental properties, thickness is perhaps most easily determined. Differences of a few ten-thousandths of an inch are instantly detected by trained fingers, and the exact measurement of thickness to ten-thousandths of an inch is easily made by means of several forms of micrometer

employed in paper testing. Thickness bears directly upon quality in case of most papers, but the way in which it bears is determined always by the purpose for which the paper is intended. Bible papers, onion skin, kraft, pergamyn, condenser paper, tissues generally, and many other special sorts gain in quality, as represented by money value, with decrease of thickness, partly because of increased difficulty and cost of manufacture, but principally because they better meet the necessities of the consumer. Other things being equal, a manifold paper which permits the making of ten copies is obviously a better paper for its purpose than one which cannot be used for more than five. The quality and value of the paper used for building up electrical condensers is enormously influenced by the relative thinness of the paper, since the efficiency of the condenser depends largely upon the closeness with which the tin foil plates are brought together; but while thinness is thus important, quality in this case is finally determined by absence of pin holes, the presence of which entirely destroys the value of the paper for its purpose.

Weight per unit area is a quality factor of varying importance, although since paper is sold by the pound the lighter of two otherwise equally satisfactory papers is commonly to be preferred. This does not always hold, however, as in case of paper for conversion into celluloid. With wrapping papers weight per unit area becomes of the first importance, and when low and combined with strength commands the market, as evidenced by the rapidly extending popularity of kraft paper. With cover papers a small increase in weight may double the cost of mailing pamphlets, while obviously at equal prices per pound the cost of paper for printing a given number of pages is proportional to the weight per unit area.

Weight for bulk influences quality for most purposes, and is especially important in connection with book papers, blottings, matrix papers and box boards. With book papers, indeed, this factor is often a good exponent of general quality, since low weight for bulk implies a minimum of filler, the

use of high-grade stock and skilful treatment in the beater. English book papers are notable for their bulking property and moderate weight. Where an edition involving a number of volumes of varying amount of text is to be made, the bulking property of the paper for the different volumes should be in inverse proportion to the number of pages in the volumes in order that the volumes themselves shall run uniform in size. Laid papers bulk more than wove papers of the same composition, and the bulking quality of different fibers varies over a wide range, esparto making an especially bulky paper. The use of mineral fillers, prolonged beating, hard calendering, coating and especially the addition of barytes to the coating mixture, all tend to make the paper thin for weight. They are justified only to the extent to which they may compensate by affecting other quality factors favorably.

Strength, whether measured as resistance to bursting strain, resistance to direct pull, or determined roughly by mere tearing, is commonly regarded as one of the most direct evidences of quality. There is a large measure of justification for this conclusion since high strength generally implies good stock, carefully prepared and skilfully manipulated. A certain minimum of strength, which, however, varies greatly with the class of paper, is an essential prerequisite of quality; while with special sorts of paper, as bag paper, kraft, paper for tags, twine, cartridge cases, etc., strength almost determines quality provided it is not associated with brittleness which makes the paper weak to sudden strain. With envelope papers, strength after folding is far more important than the strength of the flat paper. Curiously, rosin sizing reduces strength, and "wild" papers are commonly stronger than similar papers showing good formation. The "strength ratio" affords the most convenient way of reporting strength of papers. It is the quotient obtained by dividing the strength in pounds as determined by the Mullen tester, by the thickness in ten-thousandths of an inch. A paper 35–10,000 thick which tested thirty-five pounds would, therefore, have a strength ratio of 1.0. The

strongest commercial papers seldom or never show a strength ratio higher than 2.0, although we have recently prepared samples by special methods with the extraordinarily high ratio of 3.8.

The stretch of paper commonly ranges from 1 to 4 per cent. The amount of stretch shown by the paper affects quality favorably or otherwise according to the requirements of use. A large proportionate stretch improves the quality of bag papers, cartridge paper, drawing, matrix and paper for twine, artificial leather and embossing. It is very objectionable in lithograph, coated and many printing papers requiring close register, as also in paper for music rolls for mechanical organ and piano players.

In this country, up to the present time little or no attention has been paid to what in case of most papers is one of the most reliable and significant indications of general quality, namely the ability of the paper to withstand wear. Paper for money or for permanent records, loose leaf books, maps, school books, works of reference, blue prints, children's books, wrapping, card stock for catalog files, folders, and many other uses, should exhibit this property in the highest degree consistent with other requirements of the specification. Although in the past reliable methods and apparatus have not been available, in the United States at least, for determining wearing power, there is no longer any excuse for ignoring this essential element of quality, the numerical value of which may now be determined with the utmost accuracy with standard apparatus.

The capillary power of a paper, or its tendency to absorb ink or water, may be given sufficiently accurate expression by simple methods of testing. The bearing of the results upon quality depends entirely upon the class of paper tested. With due regard to other factors, the quality of writing papers rises as the capillary power falls, the quality of blotting paper is almost wholly determined by its capillary power; matrix papers and papers for celluloid manufacture or for conversion into parchment paper, vulcanized fiber or roofing must have high capillary power, that of

printing papers should generally be only moderate if the best results in rapid printing are to be secured.

The determination of opacity is more difficult, although this property is often one upon which the quality of paper in large part depends as in case of bible paper, envelope paper, and book papers generally. A considerable degree of translucency upon the other hand is a mark of quality in bond papers, while for other writings opacity commonly suggests quality. In parchment paper, again, quality presupposes translucency, while pergamyn papers of good quality must be almost transparent.

These physical properties of paper which, taken together, and interpreted with reference to the use for which the paper is intended, are almost conclusive as defining quality, are nevertheless themselves largely functions of the composition of the sheet. For this reason any final estimate of quality must include consideration of the sorts of fiber present, their condition and proportion, the kind and amount of filler, the proportion and sorts of size, and the presence or absence of acid, bleach residues, and other chemicals likely to cause deterioration or otherwise impair quality.

Although paper of some sort may be made of almost any vegetable fiber, the number of fibrous raw materials economically available for paper making is, in view of the almost infinite variety of vegetation, surprisingly limited. Cotton, flax, jute, straw, esparto, hemp and a few woods almost exhaust the list. Nevertheless, not only does each of these fibres impart definite and often distinctive characteristics to the sheet into the composition of which it enters, but the range of variation is further enormously increased by admixture of several fibres, and the chemical and mechanical treatment which they have received by way of preparation. The best stock for any paper is easily spoiled by careless or improper methods. The stock that under skilful treatment normally yields a strong, tough, permanent sheet, may by improper beating or careless bleaching give only a weak, brittle and short-lived paper. The degree to which the

fiber substance is hydrated during beating has a profound effect upon the properties of the paper, as also the manner in which the fibers themselves have been subdivided. All this, of course, to the papermaker himself is the mere A B C of his art, but it is commonly unknown to the paper consumer or ignored by him in his estimates of quality. Quality cannot be predicated upon stock alone. It is, nevertheless, true that for many papers, especially those intended for writing and the higher grades of printing, the properties representative of the highest quality are not obtainable except through the use of a large proportion of rag stock. For insulating papers such as cable paper, however, manila stock is distinctly better than rag, and curiously enough, so is even a lime cooked straw pulp. Where great toughness is desirable, as in tag and certain wrapping papers, the highest quality is obtainable only through use of manila and similar bast fibers.

The relation of the wood fibers to quality has been a matter of controversy since the time of their introduction. As to ground wood, there is probably now no question of its unsuitability for practically every use involving permanency, since exposure for even a few hours to direct sunlight renders ground-wood papers weak and brittle. It is particularly undesirable in so-called manila papers intended for making envelopes, which, if containing much ground wood quickly lose all strength on the fold under the influence of sunlight. For wall papers, rather strangely, ground wood does not seem open to much objection, partly because no great strength is required of such papers, but principally because the surface coating with size and color protects the paper beneath. For newsprint paper, ground wood remains the only possible material in spite of some minor disadvantages for such use.

Sulphite and soda fiber, if thoroughly well cooked and carefully bleached, are probably nearly, and perhaps quite as permanent as rag stock. In fact, the examination of over 400 samples of paper from the library of the University of Berlin showed that papers composed wholly or in large

part of chemical wood fiber gave slightly less evidence of deterioration than all rag papers. Since the better grades of rag stock are considerably more expensive than chemical wood fibre, endow the paper with more wearing power and better feel and texture, the presence of wood fibers is, in most cases, properly regarded as tending to lower quality. They are highly objectionable n papers for making parchment and vulcanized fiber, which should consist wholly of cotton rag stock.

The number of cases in which mineral filler improves the quality of paper is comparatively limited, although it is well recognized that for certain uses a moderate amount of filler reacts favorably upon quality, by increasing opacity, and improving feel and finish. Filler invariably, however, lowers strength and resistance to wear, diminishes bulk for weight and tends toward brittleness. In many special papers it is wholly inadmissible.

The number of factors which are concerned with the quality of paper in its multitudinous applications to special uses is so great as to prevent consideration or even enumeration of them all. A paper for wrapping hardware or a card for mounting silver jewelry may seem to possess every desirable property, and yet be worse than useless because of a trace of sulphur. A printing paper may develop "whiskers" or clog the type by mineral filler, a coated paper may pick or develop odor, a cigarette paper may burn badly, a writing paper may allow the ink to spread because the size has been converted into peptones by overheating, a filter paper may fail to hold a fine precipitate or unduly retard the passage of liquid, and so on. Enough has been said to suggest to consumers of paper the complexity of the problems involved in the determination of quality, the importance of paper testing, and the advantages to both maker and consumer of carefully considered and intelligently drawn specifications defining quality as a function of intended use.